International Journal of Electrical and
Electronics Engineering Research (IJEEER)
ISSN(P): 2250-155X; ISSN(E): 2278-943X
Vol. 5, Issue 4, Aug 2015, 15-22

ENRICHMENT OF AVAILABLE TRANSFER CAPABILITY USING TCSC

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ABSTRACT

A FACTS device such as TCSC provides electromechanical damping between large electrical systems by modulating the reactance of one or more specific interconnecting power lines. In other words, the TCSC will provide a variable capacitive reactance. In the electricity market, the location of the devices and their control can significantly affect the operation of the system. Optimal location and control of these devices will be very important for the power market regulators.

In this the use of TCSC to maximize Available Transfer Capability generally defined as the maximum power transfer. By Using IEEE 30 BUS System we can get location of the devices by ATC and maximum enhance by Genetic Algorithm Method and by a new approach to Genetic Algorithm.

KEYWORDS: Available Transfer Capability, Thyristor Controlled Series Compensator, Genetic Algorithm, New Approach to Genetic Algorithm

INTRODUCTION

Backbone of a nation's economy lies in excess of energy. The usage of energy per person is increasing gradually. Therefore it is very important to resolve this issue before it becomes crisis. Researchers has been proposed and come up with the solutions. The solution that comes in mind is to build new transmission and distribution networks. But this method is very high cost and it needs much time. In the deregulated power system one of the problems is utilization of Maximum power

The next method is to intensify the power transmitted from generating station to load centers. The advantage of this method it is money-making. In the context of deregulation and competitive market determination of the Available Transfer capability at any instant of time .The second in the context of optimum usage of existing resources and demand for quality power, study and implementation of means and methods to satisfy the requirement. This aspect is made true and feasible by the developments in Power Electronics – FACTS devices. FACTS device like Thyristor controlled series compensator (TCSC) can be employed to increase the flows in loaded lines, results in a low system loss and improved stability of network.

Available Transfer Capability

Available Transfer Capability (ATC) is a measure of the transfer capability remaining in the physical transmission network for further commercial activity over and above already committed uses.ATC can be defined as the Total Transfer Capability (TTC) less the Transmission Reliability Margin (TRM), less the sum of existing transmission commitments (which includes retail customer service) and the Capacity Benefit Margin (CBM).

ATC can be expressed as

ATC = TTC – TRM – Existing Transmission Commitments (including CBM)

Total Transfer Capability (TTC) is defined as the amount of electric power that can be transferred over the interconnected transmission network in a reliable manner while meeting all of a specific set of defined pre- and post-contingency system. Total transfer capability (TTC) is the key component for calculating Available Transfer Capability (ATC).

The two areas are formed such that the local load demand is less than the generation in one area (area1) and the generation is less than the local load demand in the other area (area2), which indicates that the power has to be transferred from one area (area1) to meet the load demand in the other area (area2). Hence the load flow analysis of the system is done and the active power flow through each transmission line is obtained. This is considered as the base case. Operating studies seek to determine limitations due to Thermal overloads Limitation, Voltage limitation, Power generated Limitation, and Reactive power generated Limitation and Load Power Limitation problems.

Objective Function with FACTS Device

$\mathbf{Min}_{\mathbf{Ppi}} = \mathbf{\Sigma}_{\mathbf{i=Ig}} \mathbf{(P_{pi})}$

Subjected to

$L (P, Q, V, \theta, X_k) = O$

$G (P, Q, V, \theta, X_k) = O$

Where,

I_g=a set of generator buses

P_{pi}=active power of generator

P=vector of power injections/extraction

Q= vector of reactive powers injections/extraction

V= vector of voltage magnitudes

θ = vector of voltage angles

X_k= FACTS device control parameter

ENRICHMENT OF ATC USING FACTS DEVICE

According to IEEE, FACTS, which is abbreviation for Flexible AC Transmission Systems, is defined as follows: “alternating current transmission systems incorporating power electronics based and other static controllers to enhance controllability and APTC” units.

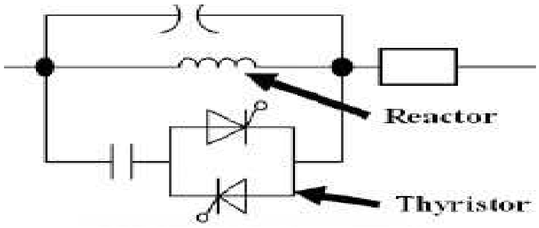

Figure1: Simple Diagram of Thyristor Control Series Capacitor

TCSC can be defined as “A capacitive reactance compensator which consists of series capacitor bank shunted by a thyristor controlled reactor in order to provide a smoothly variable series capacitive reactance”.

Thyristor controlled series compensator (TCSC) are connected in series with transmission lines. The net transfer reactance is reduced and leads to an increase in power transfer capability. The voltage profile as also improved due to the insertion of series capacitance in the line. Series compensation is usually a preferable alternative for increasing power flow capability of lines as compared to shunt compensators as the ratings required for series compensators are significantly smaller.

IPROPOSED GENETIC ALGORITHM APPROACH

In this paper a new approach is proposed to GA for the enhancement of ATC in the power system using a series FACTS device TCSC which gives a fast result with high accuracy.

Step by step procedure for proposed GA approach

Step 1: Consider 10 or 20 Pseudo random numbers from 1to 8.

Step 2: These are 1,3,5,1,2,4,6,7,9,5,8,3,10,12,3,10,7,11,5,4.

Step 3: Apply GA Approach to obtain the best fitness function.

Step 4: In the IEEE30 Bus System the Fitness function is the best possible combination of X1 (%), X2 (%) and X3(%). This combination will give the lowest loss as compared to the all off springs.

Step 5: In this Proposed Algorithm the Applied Device is kept at maximum Enhancement and the left 2 TCSC the genetic Algorithm Is been applied

Table 1: Application of G.A for IEEE 30-Bus System

S.No	(%)Series Compensation	Binary Coding	S.No	(%)Series Compensation	Binary Coding
1	10	0000	9	55	1000
2	20	0001	10	57	1001
3	25	0010	11	61.7	1010
4	30	0011	12	62	1011
5	45	0100	13	65	1100
6	47	0101	14	70	1101
7	50	0110	15	75	1110
8	54.5	0111	16	90	1111

RESULTS

The transmission lines between the corresponding interconnecting buses of two areas are called tie-lines. Now, in this system there are six tie-lines. Three major tie-lines are selected among all of them. The criterion for this is the active power flow through the line. Major tie-lines plays a significant role in the enhancement of available transmission capacity since the active power flowing through these lines is higher when compared to the other tie-lines. Thus, the major tie-lines in this system are the tie-lines between the buses 12 & 15, 9 & 10 and 16& 17.

Table 2: 6 Tie-Lines from the 2-Area IEEE 30 Bus Systems

Tie-Line	Location Between The buss	Active Power Flow	Power Flow Direction
1	6&10	3.615MW	AREA1TOAREA 2
2	**9&10**	**6.320MW**	AREA1TO AREA 2
3	**12&14**	**5.474MW**	AREA1TO AREA 2
4	**12&15**	**9.922MW**	AREA1TO AREA 2
5	16&17	4.512MW	AREA1TO AREA 2
6	28&27	-6.216MW	AREA1TO AREA 2

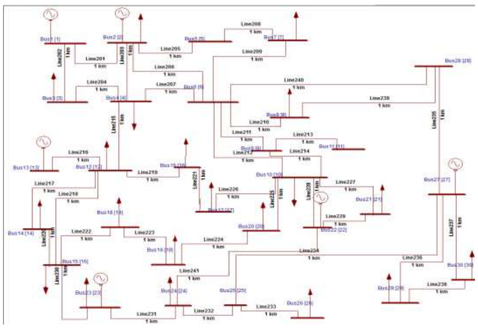

Figure 2: Construction of IEEE 30 Bus Systems

The system is divided into two areas such that, the generation is more than the local load demand in area1 and generation is less than the local load demand in area2. This indicates that the power flow direction is from area1 to area2. The algebraic sum of power flow gives the ATC power transfer from area1 to area2. It is observed to be **23.627MW**.

Table 3: ATC When Generation and Loads Are Doubled

Tie-Line	Location Between the Buses	Active Power Flow	Power Flow Direction
1	6&10	11.622MW	AREA1TOAREA2
2	**9&10**	**20.21MW**	AREA1TOAREA 2
3	12&14	16.437MW	AREA1TOAREA 2
4	**12&15**	**41.990W**	AREA1TOAREA 2
5	**16&17**	**19.040W**	AREA1TOAREA 2
6	28&27	9.007MW	AREA1TOAREA 2

The system is divided into two areas such that, the generation is more than the local load demand in area1 and generation is less than the local load demand in area2. This indicates that the power flow direction is from area1 to area2. The algebraic sum of power flow gives the ATC power transfer from area1 to area2. It is observed to be **118.417MW**

Case (1): Applying TCSC Device in each Major Tie-Line

MAJOR TIE-LINE-1: Placement of TCSC in 12 to 15 buses

Table 4: TCSC Placement between the 12 &15 Buses

Tie Line	Location Between The Buses	Active Power Flow	Power Flow Direction
1	6&10	19.886MW	AREA1TOAREA2
2	9&10	34.769MW	AREA1TO AREA2
3	12&14	20.778MW	AREA1TOAREA 2
4	12&15	80.822MW	AREA1TO AREA2
5	16&17	44.603MW	AREA1TO AREA 2
6	28&27	-46.682MW	AREA1TO AREA 2

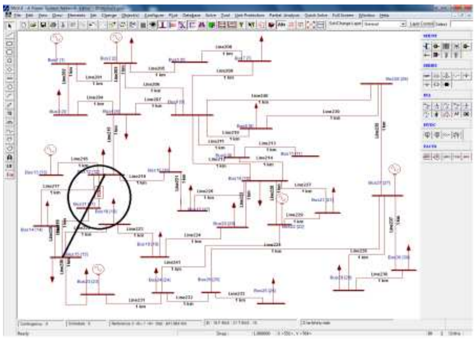

Figure 3: Placement of TCSC In 12 To 15 Buses

Now, when the TCSC is implemented in the tie-line between the buses 12 & 15, the power flow through this line is enhanced from **118.417MW** to **154.176MW**. The ATC power transferred from area1 to area2 is obtained from the algebraic sum of power flows through all the tie-lines at this value.

MAJOR TIE-LINE-2: Placement of TCSC in 9 to 10 buses

Table 5: TCSC Placement between the 9 &10 Buses

Tie line	Location Between The Buses	Active Power Flow	Power Flow Direction
1	6&10	72.212MW	AREA1TOARE2
2	**9&10**	**84.215MW**	**AREA1TOARA2**
3	12&14	27.644MW	AREA1TOARE2
4	12&15	42.965MW	AREA1TOARE2
5	16&17	57.302MW	AREA1TAREA 2
6	28&27	134.28MW	AREA1TOARE2

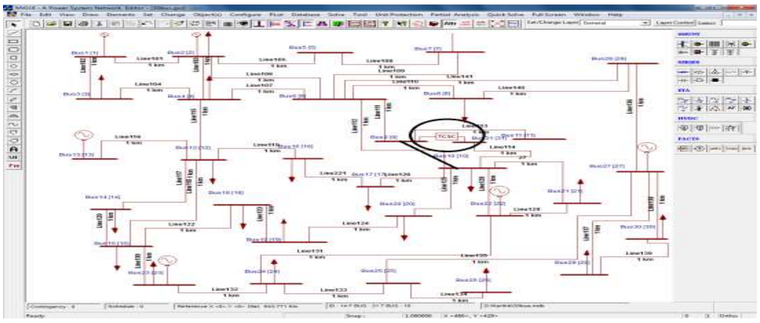

Figure 4: Placement of TCSC In 9 To 10 Buses

Now, when the TCSC is implemented in the tie-line between the buses 9 & 10, the power flow through this line is enhanced from **118.417MW** to **150.058MW**. The ATC power transferred from area1 to area2 is obtained from the algebraic sum of power flows through all the tie-lines at this value.

MAJOR TIE-LINE-3: Placement of TCSC in 16 to 17 buses

Table 6: TCSC Placement between the 16 &17 Buses

Tie line	Location Between the Buses	Active Power Flow	Power Flow Direction
1	6&10	16.953MW	AREA1TOARE2
2	9&10	10.557MW	AREA1TOARE2
3	12&14	20.619MW	AREA1TOARE2
4	12&15	57.964MW	AREA1TOARE2
5	16&17	29.641MW	AREA1TOARA2
6	28&27	6.025MW	AREA1TOARE2

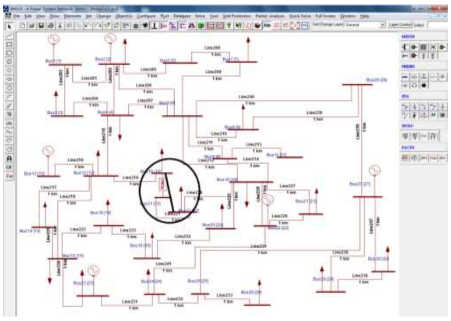

Figure 5: Placement of TCSC in 16 To 17 Buses

Now, when the TCSC is implemented in the tie-line between the buses 16 & 17, the power flow through this line is enhanced from **118.417MW** to **129.709MW**. The ATC power transferred from area1 to area2 is obtained from the algebraic sum of power flows through all the tie-lines at this value.

Case (2): Applying 3 TCSC Devices in among the 3 Major Tie-Lines by using Genetic Algorithm.

The TCSC are implemented in all the three major tie-lines at the same time and the optimal values of thyristor controlled series capacitor are obtained through Genetic Algorithm. These values are implemented and the net power transfer from area1 to area2 is obtained as follows.

Table7: TCSC Placement between the Three Major Tie-Lines Using G.A

Tie-Line	Location Between the Buses	Active Power Flow	Power Flow Direction
1	6&10	10.58 MW	AREA1TO AREA 2
2	9&10	38.562 MW	AREA1TO AREA 2
3	12&14	18.809 MW	AREA1TO AREA 2
4	12&15	75.423 MW	AREA1TO AREA 2
5	16&17	31.244 MW	AREA1TO AREA 2
6	28&27	-36.752 MW	AREA1TO AREA 2

Now, when the TCSC is implemented in the all Major Tie-Lines, the power flow through this line is enhanced from **118.417MW** to **137.866MW**. The ATC power transferred from area1 to area2 is obtained from the algebraic sum of power flows through all the tie-lines at this value.

Case (3): Applying 3 TCSC Devices in among the 3 Major Tie-Lines by a new approach to Genetic Algorithm.

The TCSC are implemented in all the three major tie-lines at the same time and the optimal values of thyristor controlled series capacitor are obtained through Genetic Algorithm.

Table 8: TCSC Placement between the Three Major Tie-Lines Using a New Approach to G.A

Tie-Line	Location Between the Buses	Active Power Flow	Power Flow Diction
1	6&10	17.199 MW	AREA1TOARE 2
2	9&10	43.865 MW	AREA1TO AREA 2
3	12&14	21.886 MW	AREA1TO AREA 2
4	12&15	86.357 MW	AREA1TO AREA 2
5	16&17	41.244 MW	AREA1TO AREA 2
6	28&27	-33.173 MW	AREA1TO AREA 2

Now, when the TCSC is implemented in the all Major Tie-Lines, the power flow through this line is enhanced from **118.417MW** to **178.066MW**. The ATC power transferred from area1 to area2 is obtained from the algebraic sum of power flows through all the tie-lines at this value.

Case (4): Comparative Analysis between different Methods applied To IEEE 30 Bus System:

Table 9: Summary of the IEEE 30 Bus

S. No	Case Study	Active Power Flow
1.	Placement of TCSC in 12 to 15 buses	154.176MW
2.	Placement of TCSC in 9 to 10 buses	150.058MW
3.	Placement of TCSC in 16 to 17 buses	129.709MW
4.	3 TCSC's are placed at a time using GA.	137.866MW
5.	3 TCSC's are placed at a time using a new approached GA	178.066MW

DISCUSSIONS AND CONCLUSIONS

The results are given for standard IEEE 30 Bus system. As seen from the tables, it is noticed that the results-maximize the total active power flow is by Thyristor controlled series capacitor at major tie-lines. It is observed that Search Method involves a lengthy computation requiring much iteration. Computation process is high. Compared to the above, GA approach attempts to get new fitness function based on reproduction, crossover and mutation. As Genetic Algorithm didn't meet my estimated output had been implemented in a new approach to the genetic algorithm and obtained at most of my required output.

By considering IEEE30 Bus System, if we consider a Large Systems, the requirement of series compensation is supposed to more then, the Search method is very complex methods to apply. At that situation the GA approach is a best suitable method. If system requires more than two TCSC's then, the requirement of chromosomes should increase. The process should be continued until the achievement best fitness function to its maximum available up to the constraints limits.

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